Bonn zoological Bulletin 71 (1): 1–7
2022 · Böhme W. & Jablonski D.
https://doi.org/10.20363/BZB-2022.71.1.001

ISSN 2190–7307
http://www.zoologicalbulletin.de

Research article
urn:lsid:zoobank.org:pub:36B7D96A-85F5-4C8E-B7A9-04128BAA0A83

Making forgotten information available: An early study on the Afghanistan Mountain Salamander *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940) (Caudata: Hynobiidae)

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Dedication. *We dedicate this paper to all enthusiastic students, teachers and researchers in Afghanistan to encourage them devoting themselves to the study of biodiversity of their country, as did the author of the study on the Afghan Mountain Salamander already nearly six decades ago.*

Abstract. The first study after the official species description of the endemic Afghanistan Mountain Salamander *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940) was published in Kabul, Afghanistan, and only in Dari Persian. We, therefore, provide here an English translation of this paper, together with so far unpublished background information on this rare and endangered amphibian, and on the former scientific German-Afghan cooperation project from the 1960s in the framework of which this study had been performed.

Key words. *Batrachuperus*, Central Asia, Hindu Kush, ecology, conservation, history.

INTRODUCTION

The hynobiid Afghanistan Mountain Salamander *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940) is endemic in a relatively small part of northeastern Afghanistan (Provinces of Ghazni, Kabul, Parwan, and Wardak; see Böhme 1982; Wagner et al. 2016; Ahmadzadeh et al. 2020). However, one dubious record of an urodelan amphibian (very likely a *Paradacytlodon*) is also known from the Chitral valley of Pakistan (Wall 1911). This means, the species is strictly endemic to the Hindu Kush mountain range and represents thus one of the most endangered amphibian species in the world (Stuart et al. 2008); according to the IUCN Red Data List of Threatened Species (Papenfuss et al. 2004), this species falls under the category "Critically endangered". Its first description (Smith 1940) had considered it the westernmost species of the otherwise East Asian (Chinese) genus *Batrachuperus* Boulenger, 1878. Up to date, there are only few mostly short, semi-popular or research papers on this rare salamander, particularly on its life habits or biology (Mertens 1970; Seufer 1974; Van Meeuwen 1977; Sparreboom 1977, 1978; Böhme 1982; Reilly 1983; Jablonski et al. 2020).

However, it is not well known that an early study of its ecology and biology after the official species description (Smith 1940) was performed by Storai Nawabi when she was a student of Prof. Dr. Ernst Kullmann (1931–1996). It was published in an Afghan journal named "Science" which had appeared in Kabul (Nawabi 1965) and was written in Dari Persian, a dialect of Farsi used in western, central and northeastern Afghanistan.

The late Dr. Josef Eiselt (1912–2001), herpetologist at the Vienna Natural History Museum, became interested in this hardly accessible manuscript when he started to work on this group of urodelans himself together with a colleague (Eiselt & Steiner 1970) by describing a new presumed congener from Iran which they named *Batrachuperus persicus* Eiselt & Steiner, 1970 (see Schmidtler & Schmidtler 1971). Thanks to his efforts, a handwritten translation of the manuscript into German was performed which made the information on this rare salamander species available at least to the German speaking scientific community so that for instance it could be used for Böhme's (1982) notes on this species. The description of another species from NE Iran, viz. *B. gorganensis*, by Clergue-Gazeau & Thorn (1978), forced more interest in these westernmost hynobiids (e.g., Stöck 1999) and finally led to a generic partition, with the erection of a new genus *Paradactylodon* Risch, 1984 for *B. gorganensis*. This concept was adopted by numerous authors to accommodate the three western *Batrachuperus* taxa as

Received: 16.06.2021
Accepted: 01.12.2021

Corresponding editor: P. Wagner
Published: 13.01.2022

opposed from their Chinese/Tibetan congeners for nearly three decades (e.g., Zhang et al. 2006; Raffaëlli 2007; Poyarkov 2010; Ahmadzadeh et al. 2011). Dubois & Raffaëlli (2012) and Dubois et al. (2021), however, regarded Risch's (1984) name, although published under A. Dubois' editorship, as incompatible with the regulations of the Code (ICZN 1999) and replaced it by two new genera, which were extremely shortly, only in a tabular form diagnosed, viz. *Iranodon* Dubois & Raffaëlli, 2012 for the two Iranian taxa and the monotypic *Afghanodon* Dubois & Raffaëlli, 2012 for the Afghan representative. Although the calculated age of the split between these two clades is 22.72 Mya (Ahmadzadeh et al. 2020) and thus would justify generic separation, we follow these authors in maintaining *Paradactylodon* as the genus name, the more as Frost (2021) has convincingly argued for the availability of *Paradactylodon* again. If it is warranted to equip the Iranian (*P. gorganensis* is nested within *persicus*!) and the Afghan species with an own monotypic genus-group name each, a subgeneric distinction would be sufficient and beneficial for nomenclatural stability. Such a distinction could also highlight the endemicity of these divergent clades. *Iranodon* should then be endemic for the Iranian Alborz and Talysh Mountains, and *Afghanodon* for (according to our current knowledge) the Afghan part of the Hindu Kush Mountains.

In this paper, we shall provide an English translation of Nawabi's (1965) paper, based on the handwritten German version, in order to make the early, rare and local information on this poorly known and critically endangered salamander available to the scientific community, the more as neither this work nor the note by Böhme (1982) are cited in the recent checklist of the Afghan herpetofauna by Wagner et al. (2016). A facsimile copy of the original Farsi-written paper is also provided as an appendix. We also provide some information on the German-Afghan cooperation (partnership contract between the universities of Cologne and Bonn on the one side, and of Kabul on the other) in the 1970s, to illustrate the intellectual climate in which the zoological research on the fauna of Afghanistan flourished in those days. The German projects in Afghanistan, mainly the foundation of a zoological garden and a zoological museum nearby were by-products, but not official parts of the mentioned university partnership (Kullmann 1970; Naumann & Nogge 1973; Nogge 2010). It was the zoo in Kabul which brought Storai Nawabi in contact with Prof. Ernst Kullmann who later became her academic supervisor in Bonn. The first Dari-written study from Afghanistan carried out and published by her (Nawabi 1965) remained largely unknown, obviously due to linguistic reasons. We here provide the first English translation of the handwritten German version initiated by J. Eiselt (some minor additions for better understanding being in square brackets).

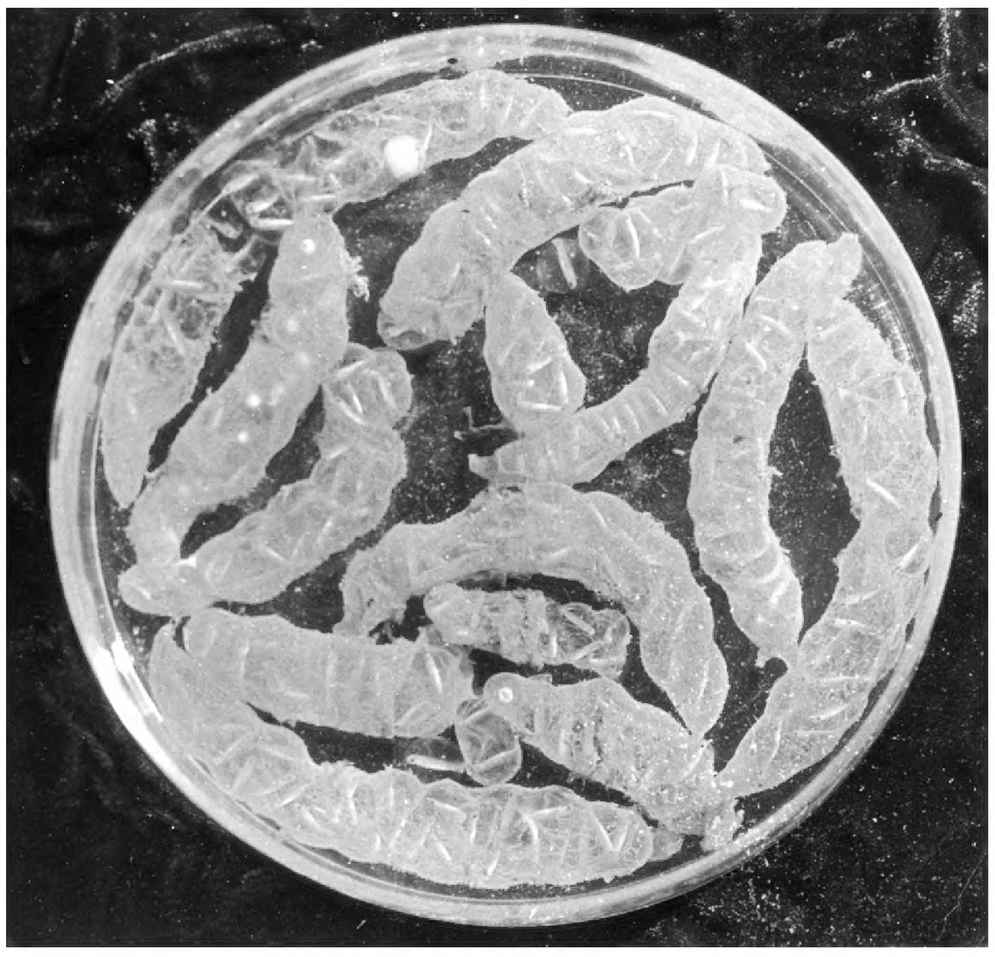


Fig. 1. (Fig. 2 in the original paper). Egg sacs of *Paradactylodon* (*Afghanodon*) *mustersi* with developing larvae. Photo: Storai Nawabi

English translation
A rare amphibian species in Afghanistan

Among the animals occurring in Afghanistan amphibians are hardly explored. Amphibians are vertebrates and form a group between fishes and reptiles. Amphibian larvae are aquatic and breathe with gills, but the adults can also live on land because they get through their metamorphosis a new respiratory system. The gills are reduced and lungs are developed.

As far as currently known, there are more than 400 bird species in Afghanistan, but only four species of amphibians. As a reason (for this poor amphibian fauna) it could be assumed that Afghanistan is a dry country where large parts are very warm in summer, but very cold in winter, particularly above 1500 m [above sea level]. *Moreover several rivers are shallow and dry completely out in summer. Some rivers, however, have such a steep gradient that they are, from this reason alone, unsuitable for such animals.*

Three of the amphibians belong to the group Anura (tailless amphibians), and two of them are frogs, the scientific names of which are (1) Rana ridibunda, *and (2)* Rana sternosignata. *The third one is a toad and is called* Bufo viridis. *It is largely distributed and can be found on creeks and in the mountains, as well as in cities and is even common and present in large numbers in Kabul.*

Only one species of the group of Urodela (tailed amphibians) which is called Batrachyperus [sic] mustersi, *has been found in 1935 and was described by Smith in 1940 as a new species (Contribution to the herpetology of Afghanistan. Annals and Magazine of Natural History, ser. II. Vol 5, 382–384).*

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Batrachyperus mustersi *belongs to the Hynobiidae, which are partitioned in five groups:*

(1) Batrachyperus *has two subgroups:* B. pinchoni, *and* B. tibetanus, *which has only been found in the mountains of South China.*
(2) Hynobius *with nine subgroups. One of them is* Hynobius keyserlinglii [sic], *occurring in Kamtschatka, Mongolia, Mandshuria, reaching Europe at the Ural Mts.*
(3) Onychodactylus *has two subgroups:* O. yaponicus [sic] *and* O. fischeri, *ranging from Korea to Japan.*
(4) Pachypalaminus *living in Japan.*
(5) Ranodon *one species of which,* Ranodon sibiricus, *occurs in western China and Turkestan.*

The family Hynobiidae has been found only in Asiatic countries and represents the early urodelans. Representatives of this family are characterised by their teeth, they are called angle-toothed urodelans. Many of them have four toes each at the fore- and hindlimbs.

B. mustersi *has been found so far only in Paghman, until now no other place has been recorded.*

During all student excursions of our Institute numerous water-breeding animals have been collected. So far, their development, though potentially quite interesting, has not yet been studied in detail.

We found B. mustersi *in a tributary or side arm of the Paghman River which runs through the Paghman valley. The area is water-rich and partly forested. Because the river itself is fast-running, its side arms provide better conditions for the development of the eggs. The eggs are forming long sac-like structures. One end is fixed at the lower part of a stone and in direct contact with water, while in* Hynobius *the eggs are deposited on plants at the water surface. The shape of the egg sacs can be seen in Fig. 2; remarkable is that one end of this structure is pointed. Each egg consists of a gelatinous substance. Interiorly is a germinal disc which grows in the course of its development until the larva hatches. Such a round egg measures 12 mm in diameter, the larva 13 mm. The following table provides some measurements:*

Values found on 17 June 1965 per egg sac

Lengt	*Width*	*Number of eggs*
15 cm	*2.2*	*31*
13 cm	*2.2*	*25*
13 cm	*2.2*	*27*
10,5 cm	*2.2*	*17*
10 cm	*1.8*	*30*
10 cm	*2.4*	*27*
8 cm	*1.6*	*25*
8 cm	*2*	*21*
7 cm	*2.4*	*19*
6 cm	*2.4*	*13*

Not all of the eggs within one sac are finishing their development, some being unfertilized, some dying during the embryonic development and some being viable. For example: Out of 24 eggs, six remained unfertilized, five remained in the embryonic stage, and 13 hatched. The young larvae which leave the egg sac lie on the lower part of the bottom.

We made the observations of this procedure under artificial conditions. Whether the procedure would take place in the same way also under natural conditions, is not known. With our (limited) possibilities we were unable to keep the larvae alive, because they need sufficient amounts of oxygen and fresh water. Moreover, we are still not sure which kind of food they need. Until now, we were unable to collect larvae at exactly those places where we had found the egg sacs. We assume that the hatched larvae move to the Paghman River itself.

Young larvae have a fish-like appearance (Fig. 3) and are 14–16 mm long immediately after hatching. The whole body with tail, except of head and breast, is surrounded by an uninterrupted median fin seam which is reduced with the further development of the larva. Traces of this seam are, however, still visible in older larvae and in freshly metamorphosed animals. The larvae have three pairs of juxtaposed gills. According to our studies, the gills are still persisting in larvae up to 8.5 cm in size. With the reduction of the gills the lungs start functioning, but the beginning of the metamorphosis stage itself was not yet observed. In very young larvae, we observed filiform appendices closely behind the eyes which are subsequently lost again. These structures serve for maintaining the larva's equilibrium in the water (Fig. 3). At the beginning of the larval stage, close to the gills, the forelimbs start to develop, followed by the hind limbs later on, so that in larvae of 8.5 cm length as in Fig. 4 the gills as well as the four extremities are visible.

The larvae have a whitish ground color with small brown flecks scattered over the entire body including the fin seams, which become scarcer towards the underside and are invisible on breast and belly. During metamorphosis, dark green to brownish spots are increasing on the dorsum. The developed larvae are silvery-brown at their undersides with a greenish shine and have often ventral silver-colored spots which are not well visible in the metamorphosed animal but can persist on the lower jaw. The outer shape of the animal looks somewhat flattened and is laterally segmented (Fig. 5). An adult specimen may reach a length of 21.5 cm, the tail, with 10.5 to 11 cm, making approximately the half of the total length. Our further investigations lead to the result that after their egg deposition, the adults do not return to a

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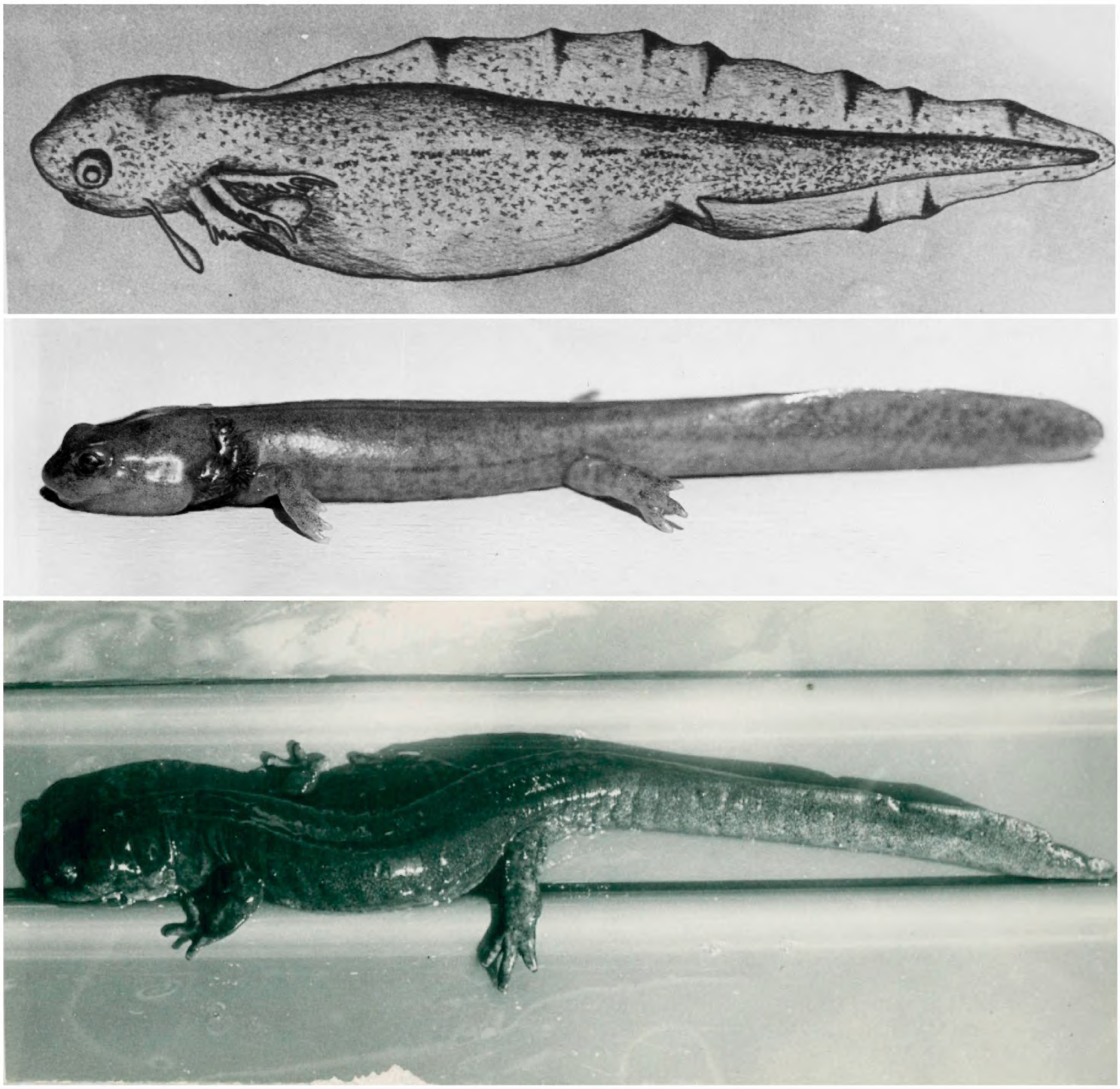


Fig. 2. (Figs 3–5 in the original paper). Young larva (above), larva ripe for metamorphosis (middle), and adult specimen (below). Drawing and photos: Storai Nawabi

terrestrial habitat but stay permanently under water. We emphasize this here because we found the salamanders exclusively in the water, submersed under stones. This was the result of our investigations as far as we could perform them in the frame of our possibilities, and which we plan to continue.

Fig. 1. Region where we found B. mustersi

Fig. 2. Eggs of these animals and their egg sacs which contain already larvae

Fig. 3. Freshly hatched larva

Fig. 4. Developed larva with gills and extremities

Fig. 5. Adult B. mustersi

My cordial thanks for his support go to Dr. Kullmann

DISCUSSION

The above text must be seen today against its historical background: It was written 57 years ago by a young Afghan female student in Kabul, Afghanistan, who carried out a study including some fieldwork on the only urodelan species of her country, supervised by a German zoologist. In fact, she was the first Afghan student who published a herpetologically-related paper from Afghanistan.

The nomenclature she used is that of her time. The subject of her study is now, after the discovery of a related species in Iran, and as stated already in the introduction, assigned to the genus *Paradactylodon* Risch, 1984, which was partitioned again and even replaced by

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Fig. 3. Adult specimen of *Paradactylodon* (*Afghanodon*) *mustersi* kept alive in Bonn. Photo: W. Böhme

two names, by Dubois & Raffaëlli (2012), the one for our species here being *Afghanodon*. The genus concept is to unite (monophyletically) related species, thus giving information on phylogenetic relationship, while monotypic genera are merely a prefix of a single species name (Richter 1943). Here, we maintain *Paradactylodon* and group *Afghanodon* only as a subgenus of the Afghan endemic brook salamander which is sufficient to express its long evolutionary isolation from the Iranian congener. One character in the short and only tabular diagnosis of *Afghanodon* and its Iranian fellow (sub)genus *Iranodon* was an abbreviation for the "adaptability in terrarium": HAT (high) for the latter, and LAT (low) for the former, certainly a weak diagnostic character for a new genus name. Moreover, several reports have shown, that also *P.* (*A.*) *mustersi* is well adaptable to captive conditions (Mertens 1970; Seufer 1974; Sparreboom 1977, 1978; Böhme 1982) and yielded several natural history data (food intake by tongue protrusion, partial terrestriality, reproductive behavior) obtained by these authors from specimens kept in aqua-terraria.

The other amphibian species mentioned in Nawabi's (1965) paper, viz. *Rana ridibunda*, *Rana sternosignata*, and *Bufo viridis*, are currently identified as *Pelophylax terentievi* (Mezhzherin, 1992) *Chrysopaa sternosignata* (Murray, 1885) and a member of the *Bufotes viridis* (Laurenti, 1768) complex (see Wagner et al. 2016), most probably *B. pseudoraddei* (Mertens, 1971) (see Dufresnes et al. 2019). All these species are well known to be present in the Paghman area (Wagner et al. 2016).

Due to the German partnership project between the universities of Cologne and Bonn on the one side, and the University of Kabul on the other, Storai Nawabi had the chance to move to Bonn for the continuation of her studies where she worked with an entomological-parasitological topic (Kullmann & Nawabi 1971) and also with an arachnological-histological issue for her master thesis (Nawabi 1974).

The ZFMK received a valuable series of more than fifty *P.* (*A.*) *mustersi* specimens including also larval stages and egg sacs, collected by Clas M. Naumann (1939–2004), lepidopterist and founder of the Zoological Museum in Kabul (Naumann & Nogge 1973), from 1974 onwards husband of Storai Nawabi and later (from 1989) ZFMK's director (Böhme 2004; Häuser 2004; Schmitt 2005). Due to his efforts, a trial was made to collect money for the reconstruction of the Zoological Museum Kabul which was completely destroyed during the long Afghan wartime, the initiative being called "*Ein Stuhl für Kabul*" (= *A chair for Kabul*). However, this initiative failed, because of the still ongoing military confrontations which are likely to increase rather than to decrease in the next time. As this causes always also a great loss of biodiversity, the endemic, small-scaled distributed and thus highly threatened Afghan mountain salamander would thus make an ideal flagship species for the greatly neglected nature conservation in Afghanistan (Jablonski et al. 2021).

Acknowledgements. We thank Dr. Storai Naumann-Nawabi, Bonn, for providing us with some information. Mrs. Hamideh Fard, Museum Koenig Bonn, gave some linguistic advice. This study was supported by the Slovak Research and Development Agency under contract no. APVV-19-0076.

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APPENDIX I

Facsimile copy of the title page of the original article in Farsi.

SCIENCE, KABUL, SPECIAL EDITION (1965) p. 21-25

Wolfgang Böhme

S. NAWABI : Ein seltener Vertreter der Amphibia in Afghanistan:

یك ذو معیشتین نادر افغانستان :

Batrachyperus mustersi

از : ستوری نوابی

در جملهٔ حیوانات افغانستان ذو معشیتین یا امفیب کمتر شناخته شده اند . ذو معشیتین شا مل حیوانات فقاری بوده ودر بین گروپ ماهی ها وخزندگان جا گرفته حیات لاروی شان با ید در آب تکامل کنند طوریکه تنفس توسط برانشی ها صورت میگیرد . اما حیات متکا مل آن میتواند درخشکه با شد طوریکه سیستم تنفس تغیر نموده : برانشی ها تنفیص می کنند وشش ها بمیان می آیند.

تا جائیکه تاحال میدانیم زیاده تراز 400 نوع پرندگان درافغانستان وتنها چهار نوع ذو معیشتین شناخته شده دلیل آن خشك بودن بسیاری از نقاط مملکت بوده طوریکه در تابستان گرم ودرزمستان بالاتر از 1500m بسیار سرد می باشد ازجانب دیگر دریا های موجوده بطورعموم دارای سطوح مختلفه اند چنانچه در تابستان قسمتاً خشك می گردند ویا بعضی از آنها به قسم دریاچه ها آنقدر جریان سریع را دارا اند که درهمچو مناطق موجودیت این حیوانات انتظار نمیرود .

سه نوع از انواع شناخته شده مربوط به گروپ « Anura »(یا ذو معشیتین بی دم) هستند که دو نوع آن بقه ها بوده که نا م هایِ علمی - Rana ridibunda و Rana sternosignata رادارامی باشد .

نوع سوم آن کوربقه است که جنس آن Bufo یاد می شود نوع مربوط این جنس Bufo viridis است که دارای ساحهٔ انتشار وسیع بوده درجوی ها بالای کوه ها ودرداخل شهر مثلاً کابل به تعداد فوق العاده زیاد ملاحظه شده میتواند.

تنها یك نوع « Urodela » (ذو معیشتن دمدار) که Batrachyperus mustersi نامیده میشود شناخته شده که درسال ۱۹۳۹ کشف شده وبه حیث یك نوع جدید درسال ۱۹٤۰ توسط Smith تشریح گردید

(Contribution to the herpetology of Afghanistan. annals and magazin cf natural History.ser ll.vol 5 382 . 384)

B. mustersi مربوط به فامیل Hynobiidae است که دارای 5 جنس می باشد

1- B. atrachyperus این جنس دارای دو نوع دیگر هم است B.pinchoni B. tibetanus که تنها در مناطق کوهستانی جنوب غربی چین شناخته شده .

2- Hynobius دارای ۹ نوع است یکی از آن Hynobius keyserlinglii شناخته انتشار آن از اورال Ural الی کمچنکا ، منگولیا ومنچوریا ودر اروپا در نیچی گورود Nishcegorod می باشد .

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